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Abstracts

Biological Activities in Fragments of Plant Cell Wall Polysaccharides, T. HAYASHI: Kagaku to Seibutsu, **29**, 150–159 (1991) (in Japanese)

Recent research data provide that oligosaccharides regulate plant defensive systems and plant development. The review focuses on assessment of the functional oligosaccharides.

Degradation of synthetic lignin (DHP) by the lignin peroxidases of *Phanerochaete chrysosporium*, T. UMEZAWA and T. HIGUCHI: Biotechnology in pulp and paper manufacture (T.K. Kirk and H.-m. Chang eds.), Butterworth-Heinemann, Boston, pp. 351–358 (1990)

Degradation of synthetic lignins (DHP) by lignin peroxidases of *Phanerochaete chrysosporium* was reviewed.

Enantioselective separations in phytochemistry, L.B. DAVIN, T. UMEZAWA and N.G. LEWIS: Recent advances in phytochemistry, vol. 25 (N.H. Fischer, M.B. Isman and H.A. Stafford eds.), Plenum, New York, pp. 75–112 (1991)

Applications of enatioselective separations with chromatography to phytochemistry were reviewed.

Chemistry of lignin degradation by lignin peroxidases, T. UMEZAWA and T. HIGUCHI: Enzymes in Biomass Conversion, ACS Symposium Series 460 (G.F. Leatham and M.E. Himmel eds.), American Chemical Society, Washington, DC, pp. 236–246 (1991)

Chemistry of lignin degradation by lignin peroxidases was reviewed.

Degradation of phenolic β-O-4 lignin model dimers by lignin peroxidase of *Phanerochaete chrysosporium*, S. YOKOTA, T. UMEZAWA and T. HIGUCHI: Mokuzai Gakkaishi, **37**, 535–541 (1991)

Degradation of a phenolic *β-O*-4 lignin substructure model dimer, 1-(4-hydroxy-3,5-dimethoxyphenyl)-2-(2-methoxyphenoxy)-1,3-propanediol (III), with lignin peroxidase of *Phanerochaete chrysosporium* was investigated. Substrate (III) was degraded to the following six compounds: guaiacol (IV), syringaldehyde (V), syringic acid (VI), 2,6-dimethoxy-*p*-hydroguinone (VII), 2-(2-methoxyphenoxy)-2-propanal (X), and 1-(4-hydroxy-3,5-dimethoxyphenyl)-2-(2-methoxyphenoxy)-2-propene-1-one (XI). The results showed that substrate (III) was degraded via alkyl-aryl cleavage, C_α-C_β cleavage, and C_α oxidation by lignin peroxidase.

Aromatic hydroxylation of methyl cinnamate to methyl 4-hydroxycinnamate catalyzed by the cell-free extracts of a brown-rot fungus *Lentinus*

Iepideus, A. OHTA and M. SHIMADA: Mokuzai Gakkaishi, **37**, 748–752 (1991)

A new aromatic hydroxylase which catalyzes the hydroxylation of methyl cinnamate to form methyl 4-hydroxycinnamate was extracted in a cell-free form from the mycelia of the brown-rot fungus *Lentinus lepideus* Fries. This enzyme also hydroxylates cinnamic acid to 4-hydroxycinnamic acid but the hydroxylation rate for this acid was about one-third that of methyl cinnamate. A new biosynthetic pathway leading from L-phenylalanine to the major secondary metabolite methyl 4-methoxycinnamate in this basidiomycete is proposed.

Degradation of a (β-O-4)-(5-5′) lignin substructure model trimer by lignin peroxidase preparation, S. YOKOTA, T. UMEZAWA, T. HATTORI and T. HIGUCHI: Mokuzai Gakkaishi, **37**, 644–648 (1991)

Degradation of a (β-*O*-4)-(5-5′) type trimer, aryglycerol-β-(dehydrodivanillyl alcohol) ether (I) by lignin peroxidase was investigated. In the degradation of substrate (I) by the enzyme, C_α-C_β cleavage, β-*O*-4 bond cleavage, and β-etherified aromatic ring (B-ring) opening products were identified as degradation products. The results showed that the B-ring of substrate (I), which sterically must be hindered more than those of aryglycerol-β-guaiacyl and -β-(2,6-dimethoxyphenyl) ethers, was oxidized by lignin peroxidase.

Formation of the lignan, (−)-secoisolariciresinol, by cell free extract of *Forsythia intermedia*, T. UMEZAWA, L.B. DAVIN and N.G. LEWIS: Biochem. Biophys. Res. Commun., **171**, 1008–1014 (1990)

A crude cell-free extract from *Forsythia intermedia* catalyses the formation of (−)secoisolariciresinol, and not its (+) enantiomer, when incubated with coniferyl alcohol in the presence of NAD(P)H and H_2O_2. This is the first report of an enzyme reaction specifically involved in the coupling reaction between two phenylpropanoid monomers to afford an optically pure lignan.

Lignan biosynthsis in Forsythia species, T. UMEZAWA, L.B. DAVIN, E. YAMAMOTO, D.G.I. KINGSTON and N.G. LEWIS: J. Chem. Soc., Chem. Commun., 1405–1408 (1990)

Both (+)-pinoresinol **6a** in *Forsythia suspensa* and (−)-secoisolariciresinol **14a** in *F. intermedia* are formed *via* a direct stereochemically-controlled coupling of coniferyl alcohol **2** derived moieties (*cf.* the typical peroxidase-catalyzed reaction in the presence of H_2O_2), and the dibenzylbutyrolactone lignan, (−)-matairesinol **10a**, in *F. intermedia* is formed from a post-coupling modification of (−)-secoisolariciresinol **14a**; this transformation has been demonstrated *in vivo*, and *in vitro* with a crude enzyme preparation, and represents the first report of an enzyme specifically involved in lignan biosynthesis.

Formation of (−)-secoisolariciresinol and (−)-matairesinol with *Forsythia intermedia* cell-free extracts, T. UMEZAWA, L.B. DAVIN and N.G. LEWIS: J. Biol. Chem., **266**, 10210–10217 (1991)

In vivo labeling experiments of *Forsythia intermedia* plant tissue with [8-^{14}C]- and [9,9-$^{2}H_2OC^{2}H_3$] coniferyl alcohols revealed that the lignans, (−)-secoisolariciresinol and (−)-matairesinol, were derived from two coniferyl alcohol molecules; no evidence for the formation of the corresponding (+)-enantiomers was found. Administration of (±)-[Ar-^{3}H] secoisolariciresinols to excised shoots of *F. intermedia* resulted in a significant conversion into (−)-matairesinol; again, the (+)-antipode was not detected. Experiments using cell-free extracts of *F. intermedia* confirmed and extended these findings. In the presence of NAD(P)H and H_2O_2, the cell-free extracts catalyzed the formation of (−)-secoisolariciresinol, with either [8-^{14}C]- or [9,9-$^{2}H_2$, $OC^{2}H_3$] coniferyl alcohols as substrates. The (+)-enantiomer was not formed. Finally, when either (−)- [Ar-^{3}H] or (±)-[Ar-^{2}H] secoisolariciresinols were used as substrates, in the presence of NAD(P), only (−)- and not (+)-matairesinol formation occurred. The other antipode, (+)-secoisolariciresinol, did not serve as a substrate for the formation of either (+)- or (−)-matairesinol. Thus, in *F. intermedia*, the formation of the lignan, (−)-secoisolariciresinol, occurs under strict stereochemical control, in a reaction or reactions requiring NAD(P)H and H_2O_2 as cofactors. This stereoselectivity is retained in the subsequent conversion into (−)-matairesinol, since (+)-secoisolariciresinol is not a substrate. These are the first two enzymes to be discovered in lignan formation.

Improvement of lignin peroxidase production by *Phanerochaete chrysosporium* in shaking culture in the presence of polyurethane foam cubes, D. MA, T. HATTORI, M. SHIMADA and T. HIGUCHI: Wood Research, **77**, 35–41 (1990)

Effects of polyurethane foam cubes and $MnSO_4$ on lignin peroxidase (LiP) production by the white-rot fungus *Phanerochaete chrysosporium* was investigated by use of shaking culture. Addition of both polyurethane cubes and $MnSO_4$ greatly enhanced the production of LiP activity up to 950 U/l culture medium. The increase in the enzyme activity is about twice as compared with that obtained from the stationary culture cultivated in the absence of these additives.

Degradation of lignin substructure model compounds in the presence of veratryl alcohol or veratryl β-D-xyloside by lignin peroxidase, T. HATTORI and T. HIGUCHI: Mokuzai Gakkaishi, **37**, 548–554 (1991)

The addition of veratryl alcohol or veratryl β-D-xyloside into the reaction mixture enhanced the C_α-C_β cleavage reaction of 1,2-bis(4-methoxyphenyl)propane-1,3-

diol (I) which is a poorer substrate for lignin peroxidase than is veratryl alcohol. Veratryl alcohol also enhanced the C_α-C_β cleavage reaction of 1-(3,4-dimethoxyphenyl)-2-(4-methoxyphenyl)propane-1,3-diol (II). The degradation rate for I in the presence of veratryl alcohol was greater than that with veratryl β-D-xyloside. However, veratryl β-D-xyloside was more stable than was veratryl alcohol during the reaction. A mixed type inhibition, comprising competitive and noncompetitive patterns, was observed by means of Lineweaver-Burk plots for the oxidation of veratryl alcohol in the presence of I. The results suggested that veratryl alcohol partly acts as a radical mediator.

Degradation of phenolic and nonphenolic syringyl and biphenyl lignin model compounds by lignin peroxidase, T. HATTORI and T. HIGUCHI: Mokuzai Gakkaishi, **37**, 542–547 (1991)

Aromatic ring opening reactions of various phenolic and nonphenolic model compounds (I–V) by lignin peroxidase were investigated. Nonphenolic syringyl (II) and biphenyl (IV) model compounds gave aromatic ring opening products (IIb, IIc, and IVc) but no ring opening product was detected from phenolic model compounds (I, III, and V). It is suggested that lignin peroxidase preferentially catalyzes the opening of nonphenolic rings but not phenolic rings. The phenolic ring of biphenyl substrate (V) was converted to catechol group.

Utilization of lignin-degrading enzymes and their biomimetic catalysts, M. SHIMADA: In, "Wood Biomass Utilization Technology" (Eds. Japan Wood Res., Society, Bun-Eidoh Publisher, Tokyo) (In Japanese) pp. 141–163, (1991)

Recent advances in research on lignin-degrading enzymes and its biomimetic catalysts were discussed from basic and applied aspects.

Biodegradation of Cellulosic Materials, M. SHIMADA and M. TAKAHASHI: Wood and Cellulosic Chemistry (D.N. Hon and N. Shiraishi, eds.), pp. 621–663 (1991)

Recent advances in research on biodegradation of cellulose in wood were reviewed. Biochemical significance of nitrogen-nutrient recycling system in higher plants and wood-rotting fungi is proposed in relation to carbon-recycling system in natural environments.

A new type of *O*-methyltransferase involved in the biosynthesis of metabolites of a brown-rot fungus *Lentinus lepideus*, A. OHTA, M. SHIMADA, T. HIGUCHI and M. TAKAHASHI: Mokuzai Gakkaishi, **37**, 275–280 (1991)

Two types of *O*-methyltransferases (OMT1 and OMT2), which are involved in the biosynthesis of secondary metabolites in *Lentinus lepideus* Fries, were extracted

from mycelia of this fungus. OMT1 is a new type of OMT which catalyzes the formation of methyl esters of free cinnamic acids and *p*-methoxybenzoic acids in the presence of S-adenosyl-menthionine, and the other (OMT2) catalyzes the formation of methyl ether (*O*-methylation) of the phenolic group of methyl *p*-coumarate, to methyl *p*-methoxycinnamate. Optimal pHs of OMT1 and OMT2 were found to be about 8.0 and 7,5. respectively. Activity of OMT1 was lost more rapidly than that of OMT2 during the storage of the enzyme preparations. Changes in the activities of OMT1 and OMT2 during the culture period fairly paralleled those in the amounts of metabolites accumulated in the cultures.

Biochemical relationships between biodegradation of cellulose and formation of oxalic acid in brown-rot wood decay, M. SHIMADA, Y. AKAMATSU, A. OHTA and M. TAKAHASHI: Intern. Res. Group/Wood Preserv., Document No. IRG/WP/1472, 1–12 (1991)

Non-enzymic hydrolysis of cellulose with low concentrations of oxalic acid was examined. The incubation of pine wood pulp with 1% oxalic acid (pH 1.3) at 35°C for 4 weeks reduced the original viscosity to 60%. Reducing sugars were liberated from various cellulosic samples by the oxalic acid treatment. However, crystallinities of cellulose in those samples did not change before and after the treatments. Then, the enzymatic formation of oxalic acid was investigated in relation to cellulose biodegradation by brown-rot fungi. We succeeded in isolating oxaloacetase from the brown-rot fungus *Tyromyces palustris* in cell-free extracts which catalyze hydrolysis of oxaloacetate to produce oxalate and acetate.

During the brown-rot wood decay process, oxaloacetase may play an important role in degradation of wood carbohydrates.

Enzymatic formation of oxalate from oxaloacetate with cell-free extracts of the brown-rot fungus *Tyromyces palustris* in relation to the biodegradation of cellulose, Y. AKAMATSU, A. OHTA, M. TAKAHASHI and M. SHIMADA: Mokuzai Gakkaishi, **37**, 575–577 (1991)

Enzymatic formation of oxalic acid from oxalic acetic acid was investigated in relation to biodegradation of cellulose.

First, it was demonstrated that 1% oxalic acid (pH 1.3) is strong enough for degradation of cellulose, decreasing the viscosity. Second, oxalic-acid-producing enzyme activity was detected from the cell-free extracts of the brown-rot fungus *Tyromyces palustris*. Then, the importance of the acid-catalyzed hydrolytic process was proposed against the hither-to proposed Fenton's system, to account for the rapid decrease in DP of cellulose during the incipient process of the brown-rot decay.

Microbial, Enzymatic, and Biomimetic Degradation of Lignin, M. SHIMADA

and T. HIGUCHI: Wood and Cellulosic Chemistry (D.N. Hon and N. Shiraishi, eds), pp. 557–619 (1991)

Lignin biodegradation research works were reviewed from the broad aspects, including microbial, enzymatic, and biomimetic view points. The importance of nitrogen-recycling in biosynthesis of lignin by plants has been focused, in view of the nitrogen starvation which might occur constantly during differentiation of xylem tissues of woody plants.

Tree species and uses of wooden remains excavated from the relics in Japan II, T. ITOH: Wood Research and Technical Notes, No. 26, 91–189 (1990) (in Japanese)

This is the supplement of "Tree species and uses of wooden remains excavated from the relics in Japan", which was published in 1987 in the same journal. The data collected from 183 literatures were computer-sorted, arranged and printed out.

Tree species used for stamp materials of wooden type for Fushimiban edition, T. ITOH and S. HAYASHI: In, "Enkoji-syozou Fushimiban Mokkatsuji-kankei Rekishi-shiryou Chousa-houkokusyo", Kyoto-fu Kyouiku Iinkai, 25–27 (plates 17–20), 1991 (in Japanese)

The oldest wooden types of 50,000 pieces in Japan, which was used for so called "Fushimi-ban" printings in Tokugawa era, were found in Enkoji temple of Rinzai sect which is located in Ichijyo-ji, Sakyo-ku, Kyoto.

77 out of 78 pieces of wooden types were identified microscopically as *Prunus spp.* One piece was identified as *Magnolia obovata.*

Electron Microscopical Studies on the Deposition Route of the Bark Lectin of *Sophora japonica*, K. BABA, M. OGAWA, and K. SUMIYA: Wood Research, **77**, 1–7 (1990)

Immuno-gold electron microscopical observation indicated that the bark lectin of *Sophora japonica* is localized in the Golgi apparatus and the intravacuolar electron-dense materials, suggesting that the lectin is transported through the Golgi apparatus on the way from the ER to the vacuole. On the other hand, it was sometimes observed that ER-like endomembrane contains electron-dense materials by conventional electron microscopy. Moreover, such endomembrane appeared to fuse the tonoplast. It is possible that some of the lectin molecules or subunits may be transported through the Golgi apparatus and the others of them may be transported directly from ER to vacuole in the parenchyma cells of the bark of *Sophora japonica.*

The possibility of distinct lectin in the xylem of *S. japonica*, K. BABA, M. OGAWA, H. KURODA and K. SUMIYA: Mokuzai Gakkaishi, **36**, 1100–1104 (1990)

(in Japanese with English summary)

By Immunofluorescence microscopy the ray and the axial parenchyma cells of the xylem of *Sophora japonica* were positively reacted against anti-seed lectin antibody. This cross-reactive material in the xylem was minor and had a molecular size of 40 kDa, whereas the lectin in the phloem was dominant and consisted of three ploypeptides of 32, 33.5 and 35 kDa. Electron microscopical observation showed that vacuoles in the xylem cells had about equal size (approx. 3 μm) and contained no protein clusters, while the vacuoles in the phloem cells contained many electron-dense clusters which had been reported to include lectin. These results suggested that the xylem of *Sophora japonica* would contain distinct lectin.

Developmental changes in the bark lectin of *Sophora japonica* L., K. BABA, M. OGAWA, A. NAGANO, H. KURODA, and K. SUMIYA: Planta, **183**, 462–470 (1991)

By immunohistochemistry it was demonstrated that the lectin was localized in the ray and the axial parenchyma. Lectin was never observed in the cambium, sieve tubes nor companion cells. The distribution and localization changed in relation to tissue development. Lectin content in the bark changed during the year, the average in summer being about 50% of that in winter. The distribution of lectin in the bark in winter was similar from the innermost (youngest) to outermost (oldest) region. In contrast, in summer the innermost region hardly contained any lectin, and the outermost contained less lectin than the middle one. Lectin localization in tissues and cells differed also depending on tissue age. In new tissue, produced in the current year, lectin was absent in summer, was located in cytoplasmic layer between cell wall and vacuole in autumn, and sequestered in the vacuoles in winter. On the other hand, lectin in old tissue (formed in the previous year) was located throughout the year mainly within the vacuoles. Within the outermost (oldest) region, in which the lectin content was low in summer, the cells which bordered to the outer bark never contained any lectin in summer. The intracellular localization in autumn in new tissue, determined by immuno-gold electron microscopy, was in lumen of the endoplasmic reticulum (ER) and vesicles, with gold particles hardly present on the cytoplasm. From these findings we conclude that lectin is synthesized on the ER and most vigorously in the new tissue in autumn, and that it is mainly consumed in the outermost bark regions, where dilatation occurs and-or where cork cambium is differentiated.

List of Species Represented by Wood Specimens in the Xylarium (KYOw), S. HAYASHI: Wood Research Institute, Kyoto University, 1–315 (1990)

Wood collections of KYOw from No. 1 to 12,000 are put in order by scientific name with alphabetically.

Tree species of excavated wood from Koukamon-ooji site, S. HAYASHI: Examination Report of Kyoto Bunka Hakubutsukan, No. 5, Chap. 4, 37–38 (1990) (in Japanese)

Excavated piles (17 specimens) and plates (2) from the east-side ditch of Koukamon-ooji are identified. *Tsuga sieboldii* are identified of 5 piles, and others are all identified to *Cryptomeria japonica*. Pile of *Tsuga* is very rare.

Identification system of wood asisted by microcomputer, Y. IZUMOTO and S. HAYASHI: Memoirs of Osaka Kyoiku University, Ser. III Natural Science and Applied Science, Vol. 39, No. 1, 87–102 (1990) (in Japanese with English summary)

This paper reports development of computerized wood identification system based on Multiple entry system. The species of Japanese wood which become the object of this system are 39 as softwood and 180 as hardwood in number. This system has image data of microphotographs which show anatomical features, and any user of this system can observe microphotographs at pleasure.

Identification of tree species excavated from Sakai Kangou site, K. SHIMAJI, S. HAYASHI and S. FUKUDA: Sakaishi Bunkazai Chousahoukoku (Examination Report), No. 46, Chap. 4, 275–279 (1990) (in Japanese)

Excavated chopsticks (3 specimens), lacquer-ware (Japanese lacquer 2) and magemono (vessel 11) are identified. One of chopsticks is identified to *Cryptomeria japonica* and two are *Chamaecyparis obtusa*. Japanese lacquer are identified to *Fagus crenata* and *Celtis sinensis* var. *japonica*. Magemono are all identified to *Chamaecyparis obtusa*.

Tree species of wooden instruments excavated from Tainaka site, K. SHIMAJI and S. HAYASHI: Hyougoken Bunkazai Chousahoukoku (Examination Report) No. 60, Chap. 5, 149–150, Pl. 45–46 (1988) (in Japanese)

Wooden instrument (12 specimens) of Heian era are identified. Hoes and club handles are made by heavy hardwood, and magemono, mokkan and chopsticks are made by softwood. Identified species are as follows; *Abies firma, Chamaecyparis obtusa, Sciadopitys verticillata, Quercus acutissima, Zelkova serrata* and Cyclobalanopsis.

Tree species of wooden instruments excavated from Yamagaki site, K. SHIMAJI and S. HAYASHI: Hyougoken Bunkazai Chousahoukoku (Examination Report), No. 75, Chap. 6, 57–64 (1990) (in Japanese)

Wooden instruments (110 specimens) excavated from the under layer of the Nara era structure are identified. *Chamaecyparis obtusa* and Cyclobalanopsis are the most dominant species and magemono, pestles and tsuchinoko are the most dominant

instruments.

Tree species of wooden instrument excavated from Kami-itai site, K. SHIMAJI and S. HAYASHI: Hyougoken Bunkazai Chousahoukoku (Examination Report), No. 76, Chap. 4, 79–86 (1990) (in Japanese)

Wooden instruments (41 specimens) excavated from the site of Yayoi to Kofun era are identified. Seven coniferous species and three broadleaved tree species are identified. *Cryptomeria japonica* and *Chamaecyparis obtusa* are main species of them.

Tree species of wooden pole excavated from Higashi Muko-site, K. SHIMAJI and S. HAYASHI: Hyougoken Bunkazai Chousahoukoku (Examination Report), No. 84, Supplement, 41–43 (1991) (in Japanese)

Two poles excavated from the site of Heian era are identified to *Chamaecyparis obtusa* and *Thujopsis dolabrata*. The pole of *Thujopsis* are very uncommon.

Tree species of wooden instruments excavated from Nanukaichi site, K. SHIJIMA and S. HAYASHI: Hyougoken Bunkazai Chousahoukoku (Examination Report), No. 72-3, 48–55 (1991) (in Japanese)

Wooden instrument (132 specimens) excavated from Yayoi to Heiann era are identified. *Chamaecyparis obtusa* (85) and *Cryptomeria japonica* (28) are main species of them.

Alkyl-aryl cleavage of phenolic *β-O*-4 lignin substructure model compound by Mn (II)-peroxidase isolated from *Pleurotus ostreatus*, H. KOFUJITA, Y. ASADA and M. KUWAHARA: Mokuzai Gakkaishi, **37**, 555–561 (1991)

The commercially cultivated basidiomycete, *Pleurotus ostreatus* (Jacq.: Fr.) Kummer, produced Mn (II)-peroxidase in a glucose-peptone medium containing a high concentration of nitrogen. The enzyme was purified by diethylaminoethyl (DEAE)-Sepharose ion exchange chromatography and ion exchange high-performance liquid chromatography to be electrophoretically pure. The molecular weight of the enzyme was 42000 with a pI of 4.2. The enzyme oxidized Mn(II) to Mn(III) in a lactate buffer. The phenolic *β-O*-4 lignin substructure model compound (**I**) was degraded by the enzyme. By gas chromagotraphy-mass spectrometry, 2,6-dimethoxy-*p*-benzoquinone (**II**), 1-(3,5-dimethoxy-4-hydroxyphenyl)-2-(2-methoxyphenoxy)-3 hydroxypropane (**III**), and 2-(2-methoxyphenoxy)-3-propanal (**IV**) were identified as the degradation products. The structures of the degradation products indicate that the enzyme catalyzed alkyl-aryl cleavage of Substrate **I**.

Purification and characterization of laccase from *Lentinus edodes*, H. KOFUJITA, T. OHTA, Y. ASADA and M. KUWAHARA: Mokuzai Gakkaishi, **37**, 562–

569 (1991)

An extracellular laccase produced in wheat-bran culture by *Lentinus edodes* (Berk). Sing. was purified successively by diethylaminoethyl DEAE-Sepharose ionexchange chromatography, ion exchange high-performance liquid chromatography (HPLC) and gel-filtration HPLC to be electrophoretically pure. The molecular weight of the enzyme was 65000 with a pI of about 3.0. The enzyme oxidized guaiacol, *o*- and *p*-phenylendiamines, syringaldazine, ABTS ((2,2′-azino-bis-(3-ethylbenzothiazoline-6-sulfonate))) and catechol in the absence of added H_2O_2, whereas substrates for tyrosinase and polyphenol oxidase were not changed. Spectral analysis indicated that the enzyme contains copper ions. The phenolic β-*O*-4 lignin substructure model compound, syringylglycerol-β-guaiacyl ether (**I**), was degraded by the enzyme. By gas chromatography-mass spectrometry of the degradation products, 2,6-dimethoxy-*p*-hydroquinone (**III**), and 1-(3,5-dimethoxy-4-hydroxyphenyl)-2-(2-methoxyphonoxy)-3-hydroxypropanone (**IV**) were identified, and 2-(2-methoxyphenoxy)-3-hydroxypropanal (**VI**) was suggested to be a counter part of **III**. The structure of the degradation products indicates that the enzyme catalyzes alkyl-aryl splitting of Substrate **I**.

Delignification of lignocellulosic biomass using genetically improved basidiomycetes, M. KUWAHARA and. Y ASADA: Energy conversion and utilization with high efficiency, Subarea B: Conversion of various resources to energy, December 1990, 201–206 (1990)

The mutant strain, FL-21, of a lignin-degrading basidiomycete *Phanerochaete chrysosporium*, in which the production of lignin peroxidase (LiP) was derepressed from the reguration by nitrogen, was induced by UV mutagenesis. This mutant produced much higher activity of LiP in the glucose-peptone medium. LiPs were purified and characterized. Properties of these enzymes showed close similarity with those of the origical strain.

The gene of LiP was cloned from the genomic DNA of *P. chrysosporium*. Nucleotide sequence of the gene has revealed that the LiP structural gene contains 1116 bp of the protein-encoding sequence, of which 84 bp encode the signal peptide. The protein-encoding sequence is interrupted by eight introns. The putative eukaryotic regulatory sequences, i.e. "CATT" and "TATA" box-like sequences, are present in the 5′ flanking region.

Basidiomycetes were screened for LiP genes using DNA probes from the LiP restricted fragment of *P. chrysosporium*. Sourthern blot analysis showed restriction fragments of chromosomal DNA of *Bjerkandera adusta* hybridized with the probe. One of the LiPs, LiP-2, was purified and characterized from the culture of this fungus, showing the similar cataritic properties with LiPs of *P. chrysosporium*.

Improvement of cellulase producing mycroogranisms and production of cellulases, M. KUWAHARA: Cellulose Resources (Gakkai Shuppan Center, ed. T. Koshijima) p. 5–23 (1991) (in Japanese)

Recent approaches on improvement of cellulolytic activity of various microorganisms and genetic engeneering of cellulases are reviewed.

Methods in improvement of ligninolytic acitvity of microorganisms, M. KUWAHARA: Techniques of utilization of wood biomass (Bunei-do Shuppan, ed. The Japan Wood Research Society) p. 195–208 (1991) (in Japanese)

Recent advances in genetic engeneering in improvement of ligninolytic activity of microorganisms and characterization of genes encoding ligninolytic enzymes are reviewed.

Water-soluble Polysaccharides from the Root of *Pinus densiflora*, T. WATANABE, K. INABA, A. NAKAI, T. MITSUNAGA, J. OHNISHI and T. KOSHIJIMA: Phytochemistry, **30**, 1425–1429 (1991)

Water-soluble polysaccharides have been extracted from the root of *Pinus densiflora*. ^{13}C NMR and methylation analysis indicated that amylose, amylopectin, glucomannan and arabinan are major components of the neutral polysaccharides, while the acidic fraction consists mainly of arabinoglucuronoxylan and homogalacturonan.

Analysis of Carbohydrate-lignin Bonds in Native and Synthetic Lignin-carbohydrate Complexes by 2,3-Dichloro-5,6-dicyano-1,4-benzoquinone-oxidation, T. WATANABE, J. OHNISHI, T. IMAMURA and T. KOSHIJIMA: Abstracts of 15th International Carbohydrate Symposium, **1**, 411 (1990)

Binding sites between lignin and carbohydrate in lignin-carbohydrate complexes (LCC) from normal and compression wood of *Pinus densiflora* were compared with those of synthetic LCCs [Dehydrogenation polymer (DHP)-polyose complexes] which were prepared by the dehydrogenative polymerization of coniferyl alcohol in the presence of acetylglucomannan or glucuronoxylan. DDQ-Oxidation of the complexes indicated that acetylglucomannan were preferably bound to the lignin predominantly at primary position of hexoses, and the glucuronoxylan were linked likewise at C-2 and C-3 positions of xylan chain both in the natural and synthetic LCCs.

Structural Analysis of Lignin-carbohydrate Complexes from *Albizia falcata* Backer, T. WATANABE, T. KOSHIJIMA, T. IMAMURA and M. KARINA: Proceedings of 6th International Symposium on Wood and Pulping Chemistry, **1**, 275–279.

Lignin-carbohydrate complexes (LCCs) have been isolated from a tropical hard wood of *Albizia falcata* Backer by a modified Björkman method. After extraction

of milled wood lignin from the hard wood, LCCs were isolated by successive extraction of the residual wood meal with water and 4% aqueous NaOH solution (LCC-AE). NMR and methylation analysis indicated that carbohydrate moiety of LCC-AE was composed of 4-*O*-methylglucuronoxylan. In addition, it has been clarified by 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ)-oxidation that the glucuronoxylan was directly bound to the lignin through C-2 and C-3 positions of xylose unit by ether linkage.

Steam Explosion Pretreatment for Enzymatic Saccharification, T. SAWADA Y. NAKAMURA, M. MOHAMMED, T. WATANABE and M. KUWAHARA: Proceedings of 6th International Symposium on Wood and Pulping Chemistry, **2**, 463–469 (1991)

The application of steam explosion process in pretreatment for microbial conversion of lignocellulose into energy was studied experimentally by using a two-stage steam explosion apparatus. The exploded wood was easily separated into hemicellulose, cellulose, methanol-soluble and residual lignins. The effects of explosion on the concentrations of those components were investigated from experimental data under various operating conditions. It was found that the two-stage steam explosion system was very effective for delignification of the wood and for increasing its susceptibility to enzymatic hydrolysis and ethanol productivity from the resulting sugars.

Furthermore, the rational conditions of the steam explosion system for a higher explosion efficiency by a low energy consumption were estimated from the contour map of saccharification against steam pressure and steaming time.

Synthesis of Oligosaccharides by Hydrolase, T. WATANABE: Cellulose Resorces (Gakkai-shuppan Center, Ed. by T. Koshijima), 49–59 (1991) (in Japanese)

Recent advances in affinity chromatography of glycosidases by substrate-enzyme interaction was explained. Transglycosylation of carbohydrate-hydrolyzing enzymes was reviewed from the view point of selective synthesis of *O*-glycosidic bonds.

Binding Sites of Cell Wall Polysaccharides to Lignin Phenylpropane Units, T. KOSHIJIMA and T. WATANABE: Abstracts of International Workshop on Frontiers in Plant and Microbial Glycans, **1**, 4 (1990)

Binding site and linkage types of lignin-carbohydrate bonds in lignified plant cell walls were determined by a new method consisting enzymatic degradation, adsorption chromatography, DDQ-oxidation and Prehm methylation. Formation mechanism of LCCs was discussed based on the binding site analysis.

Preparation and structural consideration of nitrogen-containing derivatives obtained from dialdehyde celluloses, E. MAEKAWA and T. KOSHIJIMA:

J. Appl. Polymer Sci., **42**, 169–178 (1991)

Nitrogen-containing derivatives obtained from dialdehyde celluloses were prepared under different pH conditions. On the basis of the results from an analytical data and IR absorption spectra of the products, the structure and characterization of nitrogen-containing products are discussed and also evaluated concerning a hemialdal seven-membered cyclic structure proposed by Barry *et al.* (*J. Chem. Soc.*, **1953**, 3631)

Analysis of oxidized moiety of partially periodate oxidized cellulose by NMR spectroscopy, E. MAEKAWA: J. Appl. Polymer Sci., **43**, 417–422 (1991)

Periodate-oxidized celluloses (S-100, S-70, S-50) with different degrees of oxidation were prepared. It is presented in this article that oxidized moieties of partially periodate-oxidized cellulose are determined from analyses of ^{1}H and ^{13}C nuclear magnetic resonance (NMR) spectra of those reduction products and the corresponding polytriacetates.

Chemical structure of cellulose derivatives, E. MAEKAWA: in "Function-bearing celluloses", presented as the report of the sectional research committee of the Japan Wood Research Society, 16–29 (1991) (in Japanese)

A part of the report concerned with chemical structure of cellulose derivatives was reviewed.

Comformational Analysis of Regio-Selectively Substituted Cellulose Esters, T. IWATA, J. AZUMA, K. OKAMURA and F. TANAKA: Sen-i Gakkaishi (J. Soc. Fib. Sci. Tech., Japan), **47**, 379–383 (1991)

The conformation of two regio-selectively substituted cellulose esters, cellulose propionate diacetate (CPDA, 2,3-di-*O*-acetyl-6-*O*-propionyl cellulose) and cellulose acetate dipropionate (CADP, 6-*O*-acetyl-2,3-di-*O*-propionyl cellulose), has been investigated through X-ray and electron diffraction methods. CPDA crystallizes forming an orthorhombic unit cell with dimensions $a=1.358$ nm, $b=2.221$ nm and c (fiber axis) $=1.044$ nm. The unit cell of CPDA has three sets of twofold screw axes parallel to the three orthogonal crystallographic axes, and the space group of CPDA is most likely $P2_12_12_1$. On the other hand, CADP crystallizes as a monoclinic unit cell with dimensions $a=1.108$ nm, $b=1.536$ nm, c (fiber axis) $=1.500$ nm and $\gamma=90°$. CADP has a threefold screw symmetry along the molecular axis as does cellulose tripropionate (CTP). The space group is $P2_1$ with b as the unique axis.

Vibrational Properties of Chemically Modified Wood, H. AKITSU, M. NORIMOTO and T. MOROOKA: Mokuzai Gakkaishi, **37**, 590–597 (1991) (in Japanese with English summary)

Dynamic mechanical properties of eight types of chemically modified woods were investigated in relation to their structure at both cellular and molecular levels. The chemical modification employed here reduced the specific dynamic Young's modulus E'/γ for all samples except for that obtained by formalization in the vapor phase. The change of tan δ due to the chemical modification was classified into three cases: in comparison with untreated wood, the tan g 1) increased markedly, 2) increased along the regression line obtained from the relationship between log E'/γ and log tan δ for untreated wood, or 3) decreased. Case 2) occurred only when the cell walls were not modified in spite of the chemical treatment. It was found that, Case 3) occurred when the substituents or molecules introduced into the cell walls were hydrophobic or rigid in structure, while Case 1) arose when the substituents or molecules were flexible regardless of whether they were hydrophilic or hydrophobic.

Surface Compression of Coniferous Wood Lumber II. Permanent set of compression wood by low molecular weight phenolic resin and some physical properties of the products, M. INOUE, M. NORIMOTO, Y. OTSUKA and T. YAMADA: Mokuzai Gakkaishi, **37**, No. 3, 227–233 (1991)

We attempted to permanently fix the compressive deformation of three coniferous woods, sugi (*Cryptomeria japonica* D. Don), hinoki (*Chamaecyparis obutusa* Endl.), and western hemlock (*Tsuga heterophylla* Sarg.), by using a low molecular weight l-phenoformaldehyde resin (PF). Some physical properties of the products also were measured. The results obtained were as follows:

1) Wood specimens treated with the PF resin had an anti-swelling efficiency of 60 to 70% at about 20% weight percent gain. The modulus of elasticity of the products increased with increasing resin concentrations. With low PF concentrations, the modulus of rupture of the products decreased compared to that of the untreated.

2) When specimens impregnated with PF resin of more than 15% concentrations were compressed in the radial direction at 130°C, the deformations of the specimens were almost completely fixed.

3) The dimensional stability given to the cell walls was considered to contribute to the fixing of the deformations.

4) The hardnesses of the products increased with increasing compression sets and resin concentrations, and it was possible to obtain values larger than those of high-density hardwoods without any failures.

5) In uncompressed specimens, the abrasion resistance decreased for low PF concentrations, but it exceeded that of the untreated specimens with PF concentrations above 30%. On the other hand, in specimens compressed to 60%, abrasion resistance increased by about 60% regardless of the resin concentration.

6) The abrasion resistance of the specimens treated with and without PF resin increased with increasing compression set.

Surface Compression of Coniferous Wood Lumber III. Permanent set of the surface compressed layer by a water solution of low molecular weight phenolic resin, M. INOUE, M. NORIMOTO, Y. OTSUKA and T. YAMADA: Mokuzai Gakkaishi, **37**, No. 3, 234–240 (1991)

We attempted to fix the compressive deformation of surface-compressed wood specimens using a low molecular weight phenol-formaldehyde resin (PF). The effect of the initial moisture contents of specimens, before processing the compression sets of the products, were investigated. Also, the effects of concentrations of the PF water solutions on the surface properties, such as abrasion resistance and surface hardness as well as dimensional stability to moisture, of the products are discussed.

The contrasts in moisture contents and temperatures between the surface layers and the remaining portions of the specimens during compression resulted in differences in compression sets of both portions. Checks occurred in the remaining portions for almost all of the specimens conditioned to 4% moisture contents when the PF water solution was impregnated into the specimens. Therefore, moisture contents of the specimens before processing should be regulated in the range of 10 to 15% to avoid these chekcs. Abrasion resistances of the products increased compared to that of untreated specimens or those treated with low concentrations of the PF water solution. Surface hardness also increased for all of the products, although it differed from portion to portion. The compressed layer was fixed almost completely with PF treatment, and extremely great dimensional stability against thickness swelling from moisture and heat was obtained. However, remarkable warp, due to moisture changes, was observed in the products.

Surface Compression of Coniferous Wood Lumber I. A new technique to compress the surface layer, M. INOUE, M. NORIMOTO, Y. OTSUKA and T. YAMADA: Mokuzai Gakkaishi, **36**, No. 11, 969–975 (1990)

This paper deals with a new technique of compressing only the surface layers of lumber from sugi (*Cryptomeria japonica* D. Don), hinoki (*Chamaecyparis obtusa* Endl.) and western hemlock (*Tsuga heteropylla* Sarg.) to improve their surface properties such as abrasion resistance and hardness without spoiling their beautiful color tones and great specific strengths.

Narrow grooves 2 mm wide and 5 mm deep were cut across the grain at intervals of 1500 mm on one wide surface of the lumber while taking advantage of the great water penetration in the longitudinal direction of the wood. With the aid of these grooves, water was impregnated uniformly in the prescribed surface layer. Lumber

thus impregnated with water in its surface layer was irradiated by microwaves, followed by compressing in the radial direction and drying under restraint to fix the compressive deformation. The compression set of the surface layer reached about 45%, while that of the remaining portion was very small. In comparison with untreated wood, abrasion resistance and hardness increased by 40 to 50% and 120 to 150%, respectively. Although observed by a scanning electric microscope, no damage such as checks or splits was detected in any parts of the lumber.

Permanent fixation of compressive deformation of wood, M. INOUE, M. NORIMOTO: Proceedings of the International Symposium on Chemical Modification of Wood (1991)

We attempted to permanently fix the compressive deformations of wood by means of four kinds of the treatments. When the wood specimens impregnated with an aqueous solution of the PF or the MF resin of more than 15% concentrations were compressed in the radial direction, followed by curing of the resin at 130°C under restraint, the deformations were almost completely fixed. The dimensional stability given to the cell wall was considered to contribute to the fixing of the deformations. Heating or steaming at about 200°C of the compressed specimen was also effective for the complete fixing of the compressive deformations. Steaming less than 1 minute was sufficient for the fixing of the deformations with slight color changes of the specimen. The physical properties of the compressed specimen remained almost unchanged after the steaming. On the other hand, the heat treatment took more than 5 hours to fix the deformations and besides was accompanied with drastic color changes of the specimen.

Dimensional stabilization of medium density fiberboard by formaldehyde treatment, K. MINATO, M. NORIMOTO, H. SASAKI, M. SAWADA and T. YAMAMOTO: Proc. of the International Symposium on Chemical Modification of wood, Kyoto, 124–129 (1991)

Vaporous formaldehyde treatment was applied to the dimensional stabilization of medium density fiberboard (MDF). The treatment was conducted in the presence of cyclic oxymethylenes as well as paraformaldehyde. The catalysis of sulfur dioxide (SO_2) and hydrogen chloride (HCl) was compared from the respects of reaction rate and mechanical property. About 60% of antiswelling efficiency was attained accompanying 30 to 50% loss of MOR in dry state, and extreme increases of MOR and MOE in water swollen states. So far as the reaction time and mechanical properties are concerned, the HCl was somewhat preferable than SO_2. It was suggested that the dimensional stabilization of MDF is mainly attributed to the interfiber bondigs.

Dynamic mechanical properties of chemically modified wood, T. MOROOKA, H. AKITSU and M. NORIMOTO: Proceedings of the International Symposium on Chemical Modification of Wood, 92–97 (1991)

Dynamic mechanical properties of eight types of chemically modified woods were investigated in relation to their structure at both cellular and molecular levels. The chemical modification employed here reduced specific Young's modulus E'/γ for all samples except for that obtained by formalization in vapor phase. The change of tan δ values due to chemical modification was classified as follows. In comparison with unmodified wood, the tan δ values (1) increased markedly, (2) increased along the regression line obtained for E'/γ–tan δ plots for unmodified wood, or (3) decreased. The case (2) occurs only when cell wall was not modified despite the chemical treatment. It was found that, the case (3) occurs when the substituents or molecules introduced in cell wall were hydrophobic or rigid in structure, while the case (1) arised when the substituents or molecules were flexible regardless of whether they are hydrophilic or hydrophobic.

Some physical properties of newly developed cellulose derivatives, T. MOROOKA: Wood Res. Tech. Notes, No. 26, 61–77 (1990)

Dynamic viscoleastic properties of cellulose oligo-oxymethylene ether acylates, cyanoethlated cellulose, and dialcohol cellulose are described in relation to their molecular motion.

Visocleastic properties of dialcohol cellulose prepared by homogeneous periodate oxidation, T. MOOROKA and M. NORIMOTO: Sen-I Gakkaishi, **47**, No. 7, 328–333 (1991)

In accordance with the newly developed homogeneous periodate oxidation procedure, we prepared high cleavage level 2,3- dialchol cellulose (DAC) which gives off a clear and transparent film. Viscoelastic properties of DAC were investigated in relation to those of cellulose. Dynamic mechanical measurements for DAC at 110 Hz over the temperature range from −150°C to 150°C revealed two kinds of relaxation processes, which were respectively centered around −70°C and 112°C. The first process at −70°C was related to dielectric relaxation, and was regarded to be, similar to the process in cellulose, due to the motion of methylol groups. On the other hand, the cleavage of C_2-C_3 bonds of the glucopyranose ring resulted in the process at around 112°C, while no comparable process has been reported for cellulose in the similar region. This process was ascribed to the micro- Brownian motion along the main chain. From the temperature variation of the stress-elongation diagrams, the glass transition temperature Tg for DAC was estimated to be about 80°C. The DAC film above Tg showed a marked elongation reaching 200% at 112°C.

Structure and anisotropy of dielectric constant in hardwood, Y. NISHINO and M. NORIMOTO: Mokuzai Kenkyu Shiryou (Wood Research and Technical Notes), No. 26, 78–90 (1990) (in Japanese)

The dielectric constants in the three principal directions of hardwood were evaluated on the basis of the rule of mxiture using the models in which proportions of the chemical constituents in the cell wall substance and various anatomical structures in hardwoods were taken into account, and the effects of the structure on the dielectric anisotropy were discussed. The dielectric constant in the longitudinal direction was greater than those in the transverse directions as is generally recognized. In the transverse directions, the dielectric constant in the radial direction was slightly greater than that in the radial direction, and this mainly depended on arrangement of vessels, percentage of ray element, and irregular array of wood fibers. The estimated values were in satisfactory agreement with the experimental ones and could express the dielectric anisotropy in hard wood.

Possibilities of wood as a new material, M. NORIMOTO: Wood Preservation, **16**, 228–238 (1990) (in Japanese)

Possibilities of wood as a new material were discussed.

Properties rheologiques du bois modifie par traitement chimique, J. GRIL et M. NORIMOTO: Proc. Rheologie des Materiaux du Genie Civil, 25 Colloque du Group Francais de Rheologie, Grenoble, 281–292 (1990)

Une typologie des modifications chimiques du bois basée sur l'interaction entre l'eau et les constituants moléculaires de la matière lignocellulosique est proposée. Le modèle rend compte à la fois de l'expansion hygrométrique (retrait et gonflement) et du couplage hygromécanique observé lors d'un essai de fluage à humidité variable, ou "effet mécanosprptif". Un essai dé fluage en flexion en ambiance cyclique a été réalisé sur des échantillons d'un même bois résineux modifié par des traitements de types variés. Cette procédure permet de caractériser la stabilité mécanosorptive d'un bois modifié, et complète les informations sur la stabilité dimensionnelle. Un bois stabilisé vis à vis du retrait ou du gonflement "libre" peut ne pas l'être dès lors que la variation d'humidité se produit sous contrainte. C'est le cas notamment de la stabilisation au moyen d'agents gonflants hydrophiles tels que le polyéthylène glycol ou les époxydes, qui augmentent le fluage mécanosprtif au lieu de le réduire.

Quantitative analysis for preservative by isotachophoresis, K. KOJIMA and S. ISHIHARA: Mokuzai Gakkaishi, **36**, 1069–1075 (1990)

To determine formulations in an aqueous solution of inorganic wood preservatives, results of quantitative analysis by isotachophoresis were compared with those from atomic absorption spectrometry. The inorganic preservatives used were borax-boric

acid mixtures, Cr-F-Cu (CFK), and Cr-Cu-As (CCA) and F-Cr-As-phenols (FCAP) (Japan Industrial Standards K1554 and K1550, respectively). The anions and cations in the aqueous solutions generated by the preservatives were both qualitatively and quantitatively determined more accurately by isotachophoresis than by atomic absorption spectrometry. Under the usual preservative treatment conditions, where large quantitative values were obtained, reproducibility of isotachoporesis was invarably good.

Sliced veneers of sugi (*Cryptomeria japonica* D. Don), hinoki (*Chamaecyparis obtusa* SIEB. et ZUCC.] Endl.), leopard wood (*Piratinera guianensis* Aubl.) and Indian rosewood (*Dalbergia latifolia* Roxb.) were treated with the inorganic preservatives described above and used as leaching test specimens. Red and yellow lauan (*Shorea* sp.) columns treated with borax-boric acid mixtures, and western hemlock (*Tsuga heterophylla* Sarg.) columns treated with CCA and CFK commercial preservatives also were tested. Degrees of leachability of the preservatives into water (under given conditions) from treated woods were successfully quantitated by isotachophoresis.

An amino-phosphonate based wood fire-retardant and its application, N. KOBAYASHI, J.D. MALKEMUS and S. ISHIHARA: Proceedings of the Int. Symposium on Chemical Modification of Wood, 172–177 (1991)

An aqueous fire-retardant formulation for wood consisting of one part (by weight) of (dimethylphosphono) propionamide and two parts of methylated hexamethylol type melamine resin was exceptionally high in fire retardancy and in weather or leach resistance when compared with similar formulations. Depending on the requirements, the pH value of the formulation may be adjusted as necessary.

Phosphorylation of wood surface as a fire retardant treatment, S. ISHIHARA, H. GETTO and A. SUMIDA: Proceedings of the Int. Symposium on Chemical Modification of Wood, 178–183 (1991)

It's well known that phosphorus and nitrogen compound is useful chemical agent to produce fire retardant wood. In order to dry or cure such agent, in general, the following method is employed that treated wood is set in an oven after impregnation by vacuum and/or pressure method.

It, however, is found that the characteristic of treated wood by heat-press treatment used a hot press is much different from it by heat-dry treatment used an oven. That is, heat-press treatment shows much better results not only on fire retardance but also on dimention stability of treated wood than heat-dry treatment. And according to heat-press treatment, it's effective on them at even low percent of add-on obtained by easier applied method like coated.

This shows phosphorylation and polymerization to be able to improve them may

occur on wood surface.

New technology to provide multi-functions to wood through chemical treatment, Y. IMAMURA: Mokkou-kikai (Wood Working Machinery), No. 149, 9–12 (1990)

New principles to impart high-performance properties to wood was presented. Notable improvement in resistance against fungal and termite attack through chemical modification or combination with Plastic polymers and inorganic compounds was briefly described.

Detection of decay and termite attack in wood using AE monitoring, Y. IMAMURA: Mokuzai Kenkyu Shiryou (Wood Research and Technical Notes), No. 26, 38–60 (1990) (in Japanese)

New technique to detect the incipient decay of wood and the termite attack was developed using acoustic emission (AE) monitoring. AE was detected at much lower stress levels with decayed wood even in the very early stage when bended or partially compressed. Our experiment showed that monitoring of cumulative AE counts is a sensitive indicator of early decay, which has been difficult to diagnose by conventional methods. AE of the burst type was detected also from wood under termite attack. The AE event rate increased with increasing numbers of workers present, strated the feasibility while no AE events were detected from wood with soldiers only. The paper demon of using AE monitoring to nondestructively detect termite activity in the laboratory and field tests.

Structural aspects on xylem formation in excrescence-featured varieties of Sugi (*Cryptomeria japonica*), Y. IMAMURA: Mokuzai Kenkyu Shiryou (Wood Research and Technical Notes), No. 26, 201–211 (1991) (in Japanese)

The varieties of sugi have excrescent or depressed features along the log surfaces owing to the irregular curvature of growth rings, designated as "shibo-sugi", whose character is specific to each variety and propagated by hereditary. The present paper is concerned with a microscopic examination of wood structure of normal sugi and shibo-sugi to identify and classify the varieties. It is shown that each variety exhibits the peculiar characteristics of wood structure, and ray form and tracheid arrangement are important diagnostic keys in separating the varieties.

Detection of feeding behavior of termites using AE monotoring, Y. IMAMURA, M. TOKORO, M. OWADA, Y. FUJII and M. NOGUCHI: The Int. Res. Group on Wood Preserv., Document No. IRG/WP/1514 (1991)

Using acoustic emission (AE) monitoring, the feeding activity of the termite inhabiting a wood specimen was investigated. It was revealed that AEs were detected

from the wood specimens under termite-attack and the rate of AE events increased according to the number of the inhabiting termites. It was also demonstrated that AEs were generated by workers through feeding activities. Using AE monitoring technique, the effect of wood or termite species, ratio of insect-number of different castes and the circumstances conditions on the termite-feeding behavior was evaluated. AEs were detected at high rates when susceptible wood samples were attacked by the virulent *Coptotermes* sp. AE event rate also varied according to the ambient temperture, and decreased as the temperature dropped.

Morphological characters of acetylated wood exposed to weathering, Y. IMAMURA: Proceedings of the Int. Symposium on Chemical Modification of Wood, 130–135 (1991)

Resistance of acetylated wood against degradation during natural weathering was investigated at different levels of acetylation. The color difference (ΔE^*) was minimized at the acetylation level of 24% weight gain (WG) with its rapid decline from 10% WG, even though the exposure time was prolonged. Weathering led to early disintegration and enlargement of bordered pit, extensive separation of latewood tracheid walls in the middle lamella and checking oriented along microfibril angle of the S_2 layer. These characteristic patterns of cell-wall erosion by weathering were substantially unchanged in both untreated and acetylated wood. The SEM observations, however, have revealed more extensive microscopic and macroscopic checks leading to distortion of cell alignment in untreated wood and treated ones of the low-level acetylation. After exposure to natural weathering, severe intra- and inter- cell wall erosion was also observed for earlywood of untreated specimens, which explained the successive exposure of the underneath new cell layers.

Resistance of formaldehyde-treated wood to the biological deterioration, K. MINATO, S. YUSUF, Y. IMAMURA, M. TAKAHASHI: Proceedings of the Int. Symposium on Chemical Modification of Wood, 148–153 (1991)

The resistances of formaldehyde-treated wood to the attack by decay fungi and termites were investigated in connection with the degree of the treatment. At a low level of formaldehyde treatment, high decay resistance was attained, and the effect was especially remakable to a white rot fungus. The termite resistance of the formaldehyde-treated wood was pronounced to *Reticulitermes speratus*, but not so significant to *Coptotermes formosanus*. It was thought that the effect of the treatment is not attributed to direct toxicity but to starvation. It is noteworthy that the same degree of termite resistance was obtained by a liquid phase formaldehyde-treatment at room temperature as well as by the vapor phase one.

Durability and service-life of wood, M. TAKAHASHI: in "Life of polymer

materials and its estimation" (Zoku kobunshi zairyo no jumyo to sono yosoku) (Ed. K. Hayakawa), Chapter 3, 85–120, IPC Ltd., Tokyo, 482 pp., (1991) (in Japanese)

Characteristics of wood and wood-based materials, various factors relevant to their biological and non-biological deteriorations, and estimation of their lives in service were reviewed and discussed.

Effect of molecular weight of resin on biological resistance of phenol-resin treated wood, J.Y. RYU, Y. IMAMURA, M. TAKAHASHI, H. KAJITA: Proc. Int. Sym. Chem. Modification of Wood. 154–159 (1991)

Biological resistance of PF (phenol-formaldehyde) resin-treated wood was investigated in relation to the molecular weight of resins used. Seven PF-resins with average molecular weight of 369, 383, 545, 621, 791, 991 and 1143 were used for the biological tests. Sapwood blocks of Japanese cedar were impregnated with PF-resin at several levels of % (w/w) RL (resin loading) and exposed to decay fungi and subterranean termites. Decay resistance of the PF-resin treated wood was enhanced nearly with an increase of RL. Lower molecular weight resins up to 621 had the clear advantages than others for yielding above 20% ASE (antiswelling efficiency) and higher decay-inhibiting effects even at less than 10% RL. This is related possibly to their deeper penetration into wood cell wall. PF-resin treatment also affected the activity of *Copotermes formosanus*, causing the overall depletion of wood consumption with the extent of RL. However, the attack was not inhibited perfectly even at the highest 30% RL of any resin tested, although 100% mortality of fed termites was gained finally after several weeks.

Evidence for trail-pheromone precursor in termite *Reticulitermes speratns* (Kolbe) (Rhinotermitidae: Isoptera), M. TOKORO, R. YAMAOKA, K. HAYASHIYA, M. TAKAHASHI and K. NISHIMOTO: J. Chem. Ecol., **16**, 2549–2557 (1990)

Whole body extracts of the termite, *Reticulitermes speratus* were subjected to various chemical operations and bioassays to examine the presence of trail-pheromone precursor. Fractions that mainly contained fatty acid esters were obtained from hexane extracts by means of silica gel column chromatography. Trail-following activity of the fractions was activated by alkaline hydrolysis, while the original fractions did not show any conspicuous activity. Bioassays showed that the activity of hydrolyzed products was approximately 20 times as high as the original hexane extract. This suggests that the precursor candidate could be stored in termite bodies as an esterified form. Chemical analyses revealed that the complete structure of the hydrolyzed product was coincident with that of the native pheromone ((*Z,Z,E*)-3,6,8-dodecatrien-1-ol).

Histochemistry of ray parenchyma cells and tracheids associated with biosynthesis of heartwood phenols in japanese cedar, T. NOGUCHI, W. OHMURA and H. SAIKI: Mem. Coll. Agric., Kyoto Univ., **138**: 1–10 (1991)

Histochemical observation of ray parenchyma cells and tracheids associated with biosynthesis of heartwood phenols has been carried out. In intermediate wood droplets in ray parenchyma cells showed orange red with Fast blue and cytoplasmic matrix showed dark blue with ferric chloride and potassium ferricyanide. These are considered to be related with heartwood phenols and/or their precursors. Substances migrated from ray parenchyma cells to tracheids in inner intermediate wood. This process is judged to be the first phase of the biosynthesis of heartwood phenols. Substances in tracheids showed the second changes at the boundary between intermediate wood and heartwood. From the radial distribution patterns of heartwood phenols it was revealed that many of heartwood phenols had the peak in outer heartwood. It represents to be the third phase in biosynthesis of heartwood phenols.

Effects of wood species, inoculum sponge piece sizes, and initial lengths of incubation on the fungal growth on wood in the sponge test, K. TSUNODA: Mokuzai Gakkaishi, **37**, 88–92 (1991)

The applicability of the newly proposed sponge test as a laboratory testing procedure is discussed after investigating the effects of wood species, inoculum sponge piece sizes, and lengths of initial incubations on fungal growth.

Comparison of the results obtained with two wood species (*Pinus densiflora* Sieb. et. Zucc. and *Fagus crenata* Bl.) strongly supported the applicability of the sponge test on the two species.

After one to seven-day initial incubations, smaller inoculum sponge pieces (10 or 15 mm^2) failed to induce later active fungal growth on *P. densiflora* wood specimens under dry conditions possibly because of the small population density of fungal spores in the test chambers. Therefore, in any case the size of the inoculum sponge pieces should be larger to achieve a rating scale of three in maintaining a high level of fungal spores in the chambers.

Biological resistance of wood-inorganic material composites, K. TSUNODA, Y. IMAMURA, M. TAKAHASHI, S. HIRAO, H. USUI, K. NOMURA: Proc. Int. Sym. Chem. Modification of Wood, 160–165 (1991)

Double diffusion treatment which was expected to form water-insoluble deposits in timber successfully produced a good performance in controlling decay fungi (*Coriolus versicolor* and *Tyromyces palustris*) and subterranean termites (*Coptotermes formosanus*) when small treated wood blocks were subjected to laboratory tests. The highest biological resistance was recorded with the treated blocks in which barium

hydrogenphosphate (and/or tertiary barium phosphate) precipitated. Addition of small amount of boric acid seemed to enhance the resistance.

Other treatments which would form barium sulfate or barium carbonate within timber did not seem to be promising in terms of protecting treated materials from biodeterioration.

Laboratory evaluation of metallic naphthenates as wood preservatives, K. TSUNODA and M. SAKURAI: The Int. Res. Group on Wood Preserv., Document No. IRG/WP/3654 (1991)

Fungicidal and termiticidal efficiency of copper and zinc naphthenates was appraised according to Japanese standardized laboratory testing methods.

Copper and zinc naphthenates succeeded in protecting wood from decay fungi at retentions of 0.5 and 1.0 kg/m^3 as metal, respectively. [JIS A 9302 (1976)] when they were applied to vacuum/soak impregnation [JIS A 9301 (1976)]. With respect to the fungicidal performance in superficial treatment, copper naphthenate was sufficiently effective at a treating strength of 2% as Cu and zinc naphthenate was at 3% as Zn after mild weathering cycles prescribed in JWPA Standard 1 (1979).

Their termiticidal effectiveness was satisfactory at 1–2% in wood block tests [JWPA Standard 11(1) (1981)] in which pine sapwood specimens treated by brushing were exposed to subterranean termites for three weeks.

New Zealand, an advanced country for the wood preserving industry, K. TSUNODA: Mokuzai Hozon (Wood Preservation), **17**, 74–79 (1991) (in Japanese)

Wood preserving industry in New Zealand is briefly described with some statistical data on the annual production of preserved wood products, annual consumption of wood preservatives. Recent development and trend is also mentioned introducing thickened boron treatment and LOSP.

Termite bioassays for evaluation of wood preservatives, K. TSUNODA: Sociobiology, **9**, 245–255 (1991)

Seven chemicals were tested for their termiticidal efficacy according to Japanese standardized methods using the destructive Formosan termite species, *Coptotermes formosanus* Shiraki.

Organophosphates (chlorpyrifos, phoxim and tetrachlorvinphos), in general, proved more effective than others such as synthetic pyrethroids. Chlorpyrifos and phoxim showed very high contact toxicity, and all the termites were killed within a few days at a concentration of 5 ppm which was incorporated into the sandy loam substrate. In the wood block test, organophosphates, synthetic pyrethroids (permethrin and fenvalerate) and carbamate (carbaryl) performed well at low concentrations (below 0.5%) to protect timber from termite attack. The results demonstrated that

the effectiveness of the candidate chemicals was much higher than that of chlordane (a reference termiticide).

The persistence of their efficacy should be discussed further in consideration of their stability under the actual ambient conditions to evaluate the exact service life.

Laboratory evaluation of triiodoallyl alcohol as a wood preservative, D.H. LEE, K. TSUNODA and M. TAKAHASHI: Mat. u. Org., **25**, 145–159 (1990)

An organoiodine fungicide, 2-3-3-triicdoallyl alcohol (TIAA) proved to be satisfactorily effective against decay fungi in laboratory test. When applied by vacuum/soak impregnation of sapwood blocks, TIAA could perform well at retentions of 0.33–0.65 kg/m^3. In addition, TIAA could protect timber from fungal attacks by superficial treatment at concentrations of 0.25–0.50% (w/w) which were much lower than those required for currently used wood preservatives such as TBTO, metallic naphthenates and others.

TIAA itself did not have a high termiticidal efficacy as pine blocks brush-treated with 1% TIAA sustained over 5% weight loss. It caused, however, no unfavorable effect to organophosphates or permethrin when they were incorporated with them.

Laboratory evaluation definitely demonstrated that TIAA can be a potential alternative to conventional wood preservatives, although further investigation will be needed to account for the preservative performance under the actual various environmental conditions.

Application of the crossed-paper technique to the evaluation of the synergistic effects of chemicals on fungicidal efficacy, D.H. LEE, K. TSUNODA and M. TAKAHASHI: Mokuzai Gakkaishi, **36**, 1095–1099 (1990)

The mixing effect of wood preservatives was investigated using the crossed-paper technique. Two filter paper strips (0.7 × 8 cm) were treated by soaking with different chemicals (four organoiodine compounds, chlorpyrifos, and a surface active agent), and placed at right angles to each other on a fully grown mycelial mat of a test fungus in a Petri dish.

On the basis of the pattern of the inhibitory zone formed at the crossed part of the strips, resultant mixing effect was evaluated.

When organoiodine fungicides were incorporated with chlorpyrifos or a surface active agent, only 3-iodo-2-propynyl butyl carbamate (IPBC) showed the desirable synergistic effect against every wood-decaying fungus tested.

Other fungicides always did not tend to produce the synergistic effect with the addition of a surfaceactive agent. Both 4-chlorophenyl-3-iodopropargyl formal (IF-1000) and tri-*n*-butyltin oxide (TnBTO) appeared to indicate an undesirable antagonistic effect when mixed with chlorpyrifos.

Similarity of the results obtained in the present investigation and in the previous laboratory decay tests leads to the conclusion that the crossed-paper technique is suitable for the evaluation of the mixing effect of chemicals on fungicidal efficacy.

Photostability of organoiodine wood preservatives I. Progressive degradation and loss in fungal inhibition rate through photoirradiation, D.H. LEE, K. TSUNODA and M. TAKAHASHI: Mokuzai Gakkaishi, **37**, 76–81 (1991)

Effects of the photoirradiation period on the progressive degradation and loss in fungal inhibition were investigated to comprehend the photostability of organoiodine wood preservatives.

Test solutions of 400 ppm which were prepared with ethanol from four kinds of organoiodine fungicides [4-chlorophenyl-3-iodopropargyl formal (IF-1000), 3-iodo-2-propynyl butyl carbamate (IPBC), 3-bromo-2,3-diiodo-2-propenylethyl carbonate (EBIP), and 2,3,3-triiodoallyl alcohol (TIAA)] were exposed to light irradiation (sunlight and ultraviolet lamps with a wave length of 290–400 nm). Quantitative gas chromatographic analysis showed that all the preservatives were degradated through photoirradiation. The order of fungicides according to the decomposing rates was TIAA>EBIP>IF-1000>IPBC. The photostability of IPBC was greater than any other organoiodine preservatives tested. In contrast, TIAA, which originally had great fungicidal efficacy was broken down easily. The amounts of decomposed products reached a peak after 85–110 hours of irradiation. Thereafter, both the derived and the original chemicals decomposed.

Fungal inhibitory effects of each test solution were lessened after irradiation as demonstrated by the growth of test fungi on the agar medium. The decreasing order of fungal inhibition was EBIP>TIAA>IF-1000>IPBC.

Organoiodine wood preservatives when impregnated into wood also were degraded by light exposure, although no remarkable peaks of the decomposed materials were not seen. The order of the recovery rates was IPBC>EBIP=IF-1000>TIAA. The fact that over 24 days of irradiation resulted in almost constant recovery rates of the fungicides suggested that chemicals immpregnated into wood to some extent would not be decomposed because of the unexposure to light.

Photostability of organoiodine wood preservatives II. The photolytic process of preservatives, D.H. LEE, K. TSUNODA and M. TAKAHASHI: Mokuzai Gakkaishi, **37**, 261–265 (1991)

The photolytic process of four organoiodine preservatives [4-chlorophenyl-3-iodopropargyl formal (IF-1000), 3-iodo-2-propynyl butyl carbamate (IPBC), 3-bromo-2,3-diiodo-2-propenylethyl carbonate (EBIP), and 2,3,3-triiodoallyl alcohol (TIAA)] was investigated by gas chromatography (GC) and GC/Mass spectrometry (MS).

The iodopropargyl-containing IF-1000 and IPBC were converted to propargyl compounds by photolytic cleavage of carbon-iodine bond to release iodine. TIAA, in a similar manner, was converted to 1-propanol via allyl alcohol by releasing iodine.

In contrast, the photolytic process of EBIP seemed very complicated and remained mostly unknown. Bromine in the EBIP, however, was not released during the photolysis.

The evaluation of synergistic effects of chemicals on fungicidal efficacy in the crossed-paper tests, D.H. LEE, K. TSUNODA and M. TAKAHASHI: The Int. Res. Group on Wood Preserv., Document No. IRG/WP/2838 (1991)

The mixing effects of wood preservatives were evaluated using the crossed-paper technique. Two filter paper strips (0.7×8 cm) were treated by soaking with different chemicals [fungicides, a termiticide (chlorpyrifos or phoxim), a surface-active agent, a synergistic agent, and a stabilizer], and placed at right angles to each other on a fully grown mycelial mat of a test fungus in a Petri dish.

When the four organoiodine fungicides were incorporated with chlorpyrifos or surface active agent, only 3-iodo-2-propynyl butyl carbamate (IPBC) showed the desirable synergistic effect against every wood-decaying fungus tested. Other fungicides did not always tend to produce the synergistic effect with addition of a surface-active agent. 4-Chlorophenyl-3-iodopropargyl formal (IF-1000) appeared to indicate an undesirable antagonistic effect when mixed with either chlorpyrifos or a surface active agent. 3-Bromo-2,3-diiodo-2-propenylethyl carbamate (EBIP) did not show any synergistic action by mixing with chlorpyrifos and/or a surface active agent, although the fungicidal enhancement was induced satisfactorily by mixing the fungicide with chlorpyrifos, a stabilizer and/or a synergistic agent, especially against *Tyromyces palustris* and *Coriolus versicolor*.

Similarity of the results obtained in the present investigation and in the previous laboratory decay tests leads to the conclusion that the crossed-paper technique is suitable for the evaluation of the mixing effect of chemicals on fungicidal efficacy.

Fire resistance of wood-inorganic material composites, S. HIRAO, H. USHI, K. ONISHI, K. TSUNODA, Y. IMAMURA, M. TAKAHASHI: Proc. Int. Sym. Chem. Modification of Wood, 166–170 (1991)

Wood-inorganic material composites which met performance requirements of very slow burning (=semi non-combustible) materials were produced by double diffusion treatment without any detraction of original favorable properties of timber. Amount of water-insoluble deposits formed within timber was equivalent to that of cemented chip boards in volume ratio of inorganic substances to timber volume. Fire resistance of the novel wood-inorganic material composites was nearly equal to

that of cemented chip boards in terms of calorific values. Combustion rate of plywoods made of the treated veneers was 0.60 mm/min which was equal to 40% of untreated plywood.

Practical scale fire retarding door proved to satisfactorily perform when tested according to JIS A 1304, which supported the applicability of the new principle of double diffusion process for manufacturing very slow burning wood-based materials.

Production of thick low-density particleboard with a semi-continuous steam-injection press, B. SUBIYANTO, S. TAKINO, S. KAWAI and H. SASAKI: Mokuzai Gakkaishi, **37**, 24–30 (1991)

Thick low-density particleboards were produced on a test plant scale with a very short pressing time using a semi-continuous steam-injection press and their mechanical and physical properties were studied. The results are summarized as follows:

1) Thick boards, 60–100 mm, could be pressed with a total press time of 90 seconds including the steam-injection time of 8–15 sec.

2) The variations in internal bond strength and in thickness along the lengthwise direction were improved by closing the steam-injection holes of the platen areas within 300 mm from both ends of the press.

3) The *IB* strengths were comparable to those of conventionally hot-pressed boards (control boards).

4) The thickness swellings of the thick boards were reduced to 60–70% of that of conventionally hot-pressed particleboards.

Trial set-up of semi-continuous (intermittent) press with steam-injection from hot-platen surfaces and the temperature distribution, H. SASAKI, S. KAWAI, B. SUBIYANTO, Y. SAWADA and S. MATSUMOTO: Wood Industry (Mokuzai Kogyo), **45**, 409–413 (1990) (in Japanese with English summary)

A semi-continuous (intermittent) hot-press with a steam-injection device was designed and set up. Trial production of semi-strand boards with a target density, 0.4 g/cm^3 and thickness 100 mm was conducted using this newly developed press. This paper concerns details of press structure and discussion of the optimum operation condition based on measurements of the temperature distribution during pressing.

It was concluded that the optimum condition can be properly determined by controlling the steam injection time and the steam nozzle location in the press. A repeated pressing is necessary for the joint part of partilce mat between consecutive pressing steps. The proper length of overlap at the mat joint part will be discussed in the succeeding papers. Although this newly developed press was designed for experimental purposes and has low productivity, the above results show that this system of semi-continuous press with steam-injection device can be applied to an industrial

scale board manufacture.

Aligning torque generated in wood particles by an electrostatic field IV. Effect of torque and moment of inertia of particles, and orientation time on alignment angle, O.R. PULIDO, Y. YOSHIDA, S. KAWAI and H. SASAKI: Mokuzai Gaikkaishi, **37**, 135–141 (1991)

Particles from Douglas fir (*Pseudotsuga menziesii* Mirb. Franco), Port Orford cedar (*Chamaecyparis lawsoniana* A. Murr. Parl.), and western red cedar (*Thuja plicata* Donn) with different thicknesses and aspect (length/width) ratios were dropped into an electrostatic field generated by an upper-positioned electrode system. In this condition of free-fall and constant electrostatic field intensity, the average alignment angle of the particles and the logarithm of the ratio of the aligning torque over the moment of inertia show an inverse linear relationship. The moment of inertia of a particle is a more dominant factor than is the quantity of the torque generated on the particle in a condition of free-fall.

The changes in the angle between the electrostatic lines of force and the fiber direction of circular and square particles freely-suspended in an electrostatic field were measured at a constant time interval. Results showed that a certain amount of aligning torque is generated on such particles, causing a rotary motion to the particles. The aligning torque is believed to be caused by: a) dipole polarization of the hydroxyl groups and of the adsorbed water in the wood, and b) surface charge polarization caused by the movement of free electric charges on the surface of the particle to the corner nearest an adjacent electrode. The dipole polarization is instantaneous and is extremely faster, but surface charge polarization seems to be greater and is dominant. Both are functions of time, and for a short orientation time, such as those in an ordinary electrostatic mat formation system, particles are oriented along the fiber direction due to the dipole polarization.

Utilization of laminated-veneer-lumber from Sabah plantation thinnings as beam franges I. Increasing confidence limits in properties by processing into laminated-veneer-lumber, Q. WANG, T. HAYASHI, H. SASAKI and Y. NAGAYA: Mokuzai Gakkaishi, **36**, 624–631 (1990) (in Japanese with English summary)

The mechanical properties of laminated-veneer-lumber (LVL, 2.5 mm veneer, 9-ply) manufactured separately from four fast growing species [*Acacia mangium* Wild. (AM), *Eucalyptus deglupta* Bl. (ED), *Gmelina arborea* Linn. (GA), and *Albizia falcata* Back. (AF)] of Sabah (Malaysia) forest plantation thinnings are discussed.

1) The bending strengths of LVL from all four species were exceedingly greater than the minimum values required by Japan Agricultural Standards (JAS) for first-grade structural LVL, although the Young's modulus in bending of the LVLs from

GA and AF were a little less than the minimum values. Proper dispersion of veneer scarf-joints in LVL should be given full consideration because the fractures usually occur at these joints.

2) The shear strength of LVL from all species except AF met the JAS, first-grade. Wood fractures developed mostly at the lathe checks of the veneers, whereas very few glue line failures were observed. Shear strengths after cyclic immersion (4 h boil, 20 h drying, 4 h boil) were about 70% of those in LVL in an air-dry condition.

3) The average value of modulus of elasticity of LVL of each species increased 16% compared to those of dimension lumber because of the effect of compaction, and the deviations decreased by more than 50%.

4) Although there were no increases in the average moduli of rupture (*MOR*) of LVL of all species compared to those of dimension lumber, the standard deviation was significantly small, and the 5% exclusion limit was estimated to increase by from 16% (ED) to 73% (AF) more than those of dimension lumber. Therefore, the strength performance and safety in structural use are greatly improved by processing wood into LVL.

5) Simulation models based on the central limit theorem, as well as the fracture mechanics theory, could estimate the distribution function of specific gravity, modulus of elasticity (*MOE*), and *MOR* of LVL from those of solid wood.

Pressure distribution along gluelines and bonding properties I. In a glueline pressed by clamps, P. YANG, M. HATA, H. SASAKI and S. OSHIUMI: Mokuzai Gakkaishi, **37**, 611–618 (1991) (in Japanese with English summary)

The pressure distribution in a glueline, of two-wood adherends pressed by bolt-clamps without caul-plates was calculated. When the distance between the clamps was extremely great compared to the thicknesses of the adherends, the distribution was non-uniform. The pressure distribution was calculated by means of the Finite Element Method of numerical analysis and was measured using pressure-sensitive film (Presscale Fuji Film Co.). In a reference experiment, the relationship between the bond strength of gluelines and the distances from the clamp positions was investigated with varing thickness of Douglas-fir (*Pseudotsuga menziesii* ((Mirb.)) Franco) adherends and kinds of resin adhesives. The results were as follows:

1. The pressure distribution in the glueline measured by a pressure-sensitive film was qualitatively in good agreement with the results of the numerical analysis using the Finite Element Method.

2. Pressure in the glueline decreased as the distance from the clamps became greater, and there was almost no pressure in the glueline distant by 1.2～1.5 times the adherend thickness from the clamping edge.

3. In the case where the distance between clamps was great, an opening occurred between the adherends at the midpoint between the clamps. The height of the opening dended on the bending stiffness of the adherends.

4. The bond strength at the place where the pressure was the least (at the midpoint between the clamps) was not necessarily the smallest. This tendency is attributed to the gap-filling properties of adhesives and the warp of the adherends due to additional moisture from the adhesive spread on the surfaces of the adherends.

Pressure distribution along gluelines and bonding properties II. In gluelam production with a system pressing with clamps, P. YANG, M. HATA and H. SASAKI: Mokuzai Gakkaishi, **37**, 619–624 (1991) (in Japanese with English summary)

This paper deals with the relationship between the pressing system and the pressure distribution along the glueline in glulam pressed by clamps. The results of the numerical analysis using the two-dimensional Finite Element Method were in agreement with the experimental results measured with pressure-sinsetive film (Presscale Fuji Film Co.). The effects of the distance between two clamps, the thickness of the caul plates, and the elasticity of the rubber cushion sheet on the pressure distribution were investigated. Based on the results a reasonable pressing system for the manufacture of glulam was established. The results were as follows:

1) Pressure by clamps was transmitted to a wider region, and the variation of pressure along the glueline decreased with increases in the flexural rigidity of the cauls, even if the distance between clamps was long.

2) The variation of pressure in the layers of the glulam decreased and the pressure distribution also became more uniform as the distance from the surface layer increased.

3) The pressure distribution was uniform when the clamps were set-up at positions $L/4$ (L=length of glulam) from both ends of the glulam, that is, the distance between clamps was one-half ($L/2$) of the length of the glulam. The pressure was greater in the region between the clamps than in the outer regions beyond the clamps when this distance was shorter, but the opposite was true when this distance became longer.

4) Pressure distribution was more uniform and the pressure concentration was reduced when the elasticity of the rubber cushion sheet decreased (softer cushion). This effect became more significant when the distances between clamps became longer.

5) The effect of the distances between clamps on the outer gluelines was greater than on the center glueline. When the distances between clamps were about 1.4 times the thickness of the glulam, all gluelines showed same pressure at the midpoint

between the clamps. This would be very helpful in the selection of a suitable pressing system for glulam production.

Phenolic-resin treated compressed laminated veneer lumber, S. KAWAI, H. SASAKI, H. INUI and K. NAKATA: Proceedings of the International Symposium on Chemical Modification of Wood, p. 118–123, May 17–18, 1991, Kyoto.

Rotary veneers of Japanese cedar (*Cryptomeria japonica* D. Don) were soaked in a phenolic resin solution with low molecular weight. Six-ply compressed LVLs with different thicknesses (17–6 mm) were manufactured, and their mechanical and physical properties were determined. The results obtained are as follows; 1) The percent weight gain of resin (WPG) to the green veneers was not affected by the soaking time, but by the initial moisture content of veneers. The WPG of air-dry and oven-dry veneers increased with increases of soaking time, and the rate of penetration into these veneers was much greater than that into green veneers. The WPG of sapwood veneers was much greater than that of heartwood veneers. 2) Both the moduli of elasticity and rupture had linear relationships to the density of LVL. 3) The dimensional stability of compressed LVL was highly affected by the WPG, and for phenolic resin a WPG of around 40% is needed in order to obtain good dimensional stability of the compressed LVL with a compressive ratio around 50%.

Carbon overlaid particleboard as an electromagnetic shield and fire resistive material, S. KAWAI, S. ISHIHARA, I. IDE, Y. YOSHIDA and M. NAKAJI: Proceeding of the 1990 International Timber Engineering Conference, Vol. 1, p. 74–79, October 23–25, 1990, Tokyo

The electromagnetic shielding and the heat and flame shielding performance of graphite-overlaid particleboards were evaluated in full-scale tests.

The shielding efficiency of 30 mm thick and 0.60 g/cm/ dense overlaid board with 10% graphite layers was over 40 dB against electric fields, which satisfied a standard for shielding materials for partitions and enclosures of office buildings and computer aids. This shielding efficiency increased with an increase of the ratio of overlay.

The fire endurance of graphite overlaid particleboards was improved both in the time delay in ignition and in temperature rise at the unexposed surface, when compared with controls (particleboards) at the same board thicknesses and density, due to low combustibility of the graphite overlay. Longer fire retardance was observed in thicker boards. However, further increases of the weight ratio of graphite overlays in 40 mm thick boards did not give remarkable improvement for fire retardance.

The time to reach the critical temperature of 260°C at the unexposed surface of control particleboards increased with increases of board surface density, that is, mass per unit area (density × thickness of board) in the same manner as those of commercial

particleboards, low-density particleboards, and plywood panels. Non-combustible commercial boards had similar relationships to those of wood based panels, but their fire endurance times were rather lessened when compared at the same surface density. On the other hand, graphite overlays prolonged this endurance time by 10–35%.

Gluelam, Wood-Composition Boards, S. KAWAI: Wood Technology (Mokuzai no Kogaku), Bun-ei do Pub. Co. Ltd., p. 18–25, p. 52–37 (1991)

The classification and the properties of gluelam and wood-composition boards are summarized and the recent development of these composite wood is reviewed.